

What is the aim of DarkSide (E-1000)?

Who are DarkSide?

What is the design of DarkSide and why?

What is Fermilab involvement in DarkSide?

What is status and schedule of DarkSide?

A.O.B.

<http://darkside.lngs.infn.it/>

# DarkSide: Direct Search for WIMP Dark Matter using liquid argon as target.

- DS-50 - 50 kg active, 33 kg fiducial sensitivity  $2 \times 10^{-45} \text{ cm}^2$  in 3 yr run.

Funded by DOE, INFN, NSF

- DS-G2 - 5 tonnes total, 3.3 tonnes fiducial sensitivity  $2 \times 10^{-47} \text{ cm}^2$  in 3 yr run
- R&D funded by NSF (NSF DCL, May 1 2012)
- R&D requested to DOE (G2 FOA, Jul 6 2012)

# DarkSide Collaboration

## China, Italy, Poland, Russia, Ukraine, UK, & U.S.

Augustana College (SD), USA  
Black Hills State University, USA  
Fermilab, USA  
IHEP, Beijing, China  
INFN Laboratori Nazionali del Gran Sasso, Italy  
INFN and Università degli Studi Genova, Italy  
INFN and Università degli Studi Milano, Italy  
INFN and Università degli Studi Napoli, Italy  
INFN and Università degli Studi Perugia, Italy  
INFN and Università degli Studi Roma 3, Italy  
Institute for Nuclear Research, Kiev, Ukraine  
Jagellonian University, Poland  
Joint Institute for Nuclear Research, Russia  
Princeton University, USA  
RRC Kurchatov Institute, Russia  
St. Petersburg Nuclear Physics Institute, Russia  
Temple University, USA  
University of Arkansas, USA  
University College London, London, UK  
University of California, Los Angeles, USA  
University of Hawaii, USA  
University of Houston, USA  
University of Massachusetts at Amherst, USA  
Virginia Tech, USA

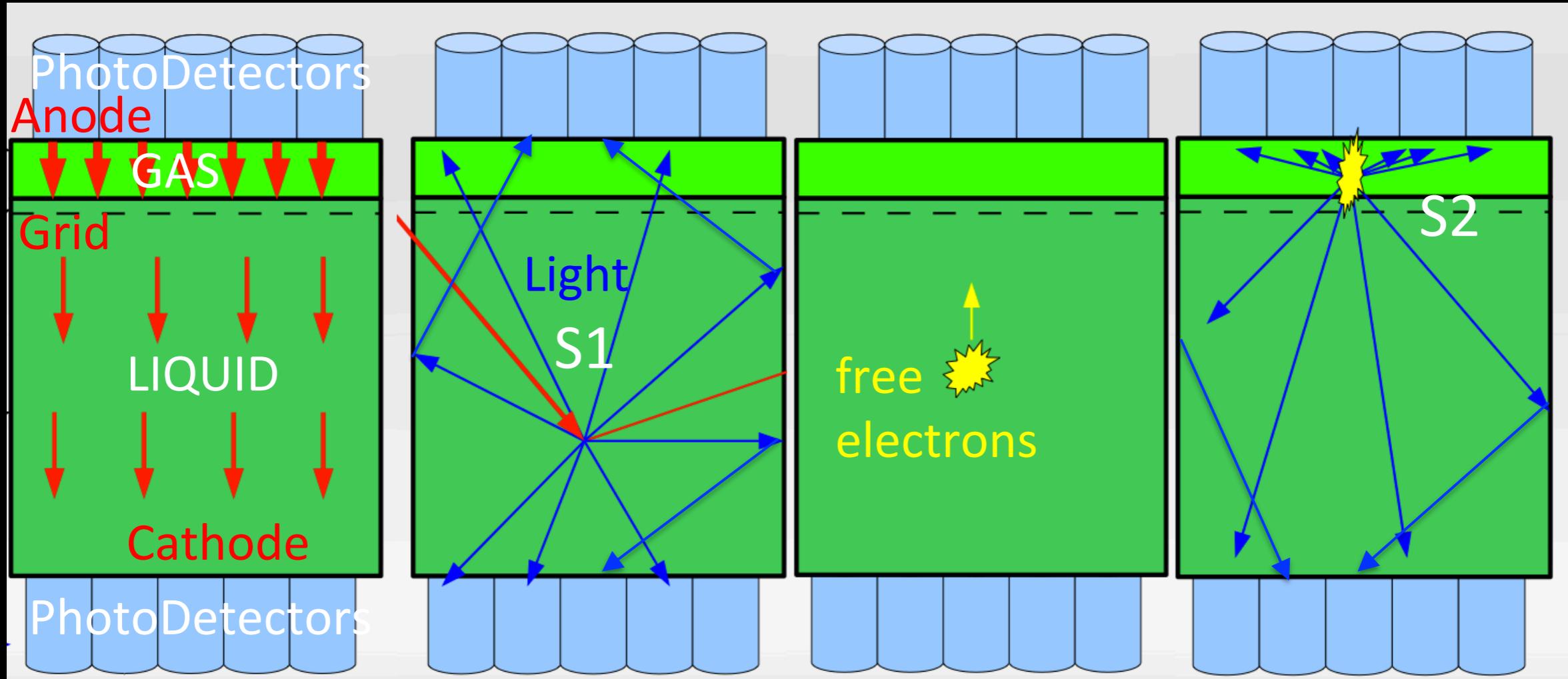
# Direct Detection Requirements

- Low energy nuclear recoils (< 100 keV)
  - Low rate ( $\sim$  few events/ton/yr for  $10^{-47}$  cm $^2$ )
- ⇒ Maximize detector sensitivity (light yield)
- ⇒ Background avoidance, rejection, measurement

Detector designed for unambiguous discovery

# Two-phase Argon TPC Schematic

Argon produces scintillation light and allows long (meters) free electron drift.



Liquid Phase;  
Gas Pocket above;  
Electric Field in both.  
~ 1kV/cm (Liquid),  
few kV/cm (gas)

WIMP interacts;  
Nucleus Recoils  
Argon produces  
light and free  
electrons.

Electrons drift up  
in liquid and  
.....  
are extracted  
by field of ~3 kV/cm

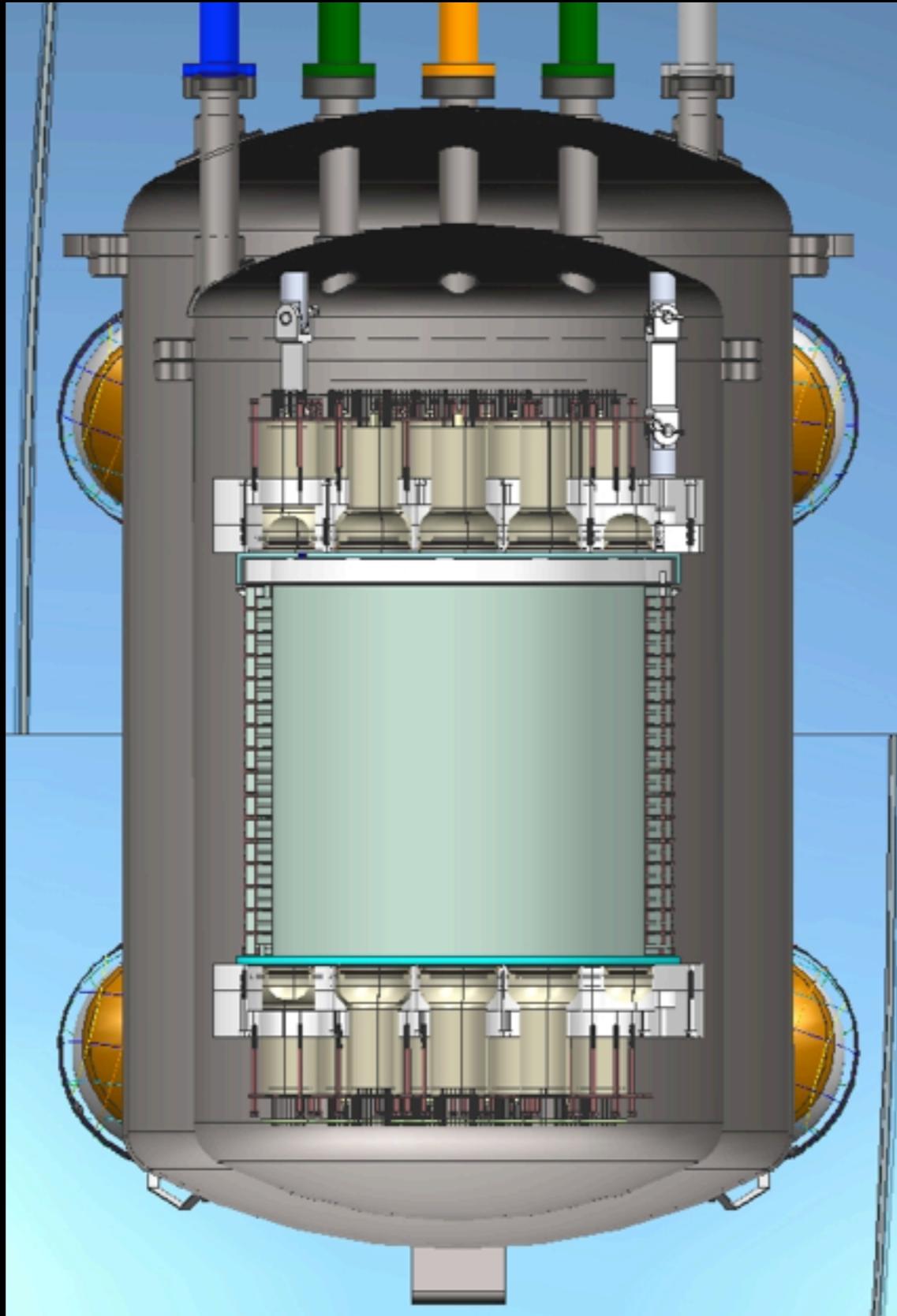
into gas region  
where they produce  
secondary  
fluorescence (**S2**),  
proportional to  
number of e's.

# DarkSide

# Aim at zero-background technology

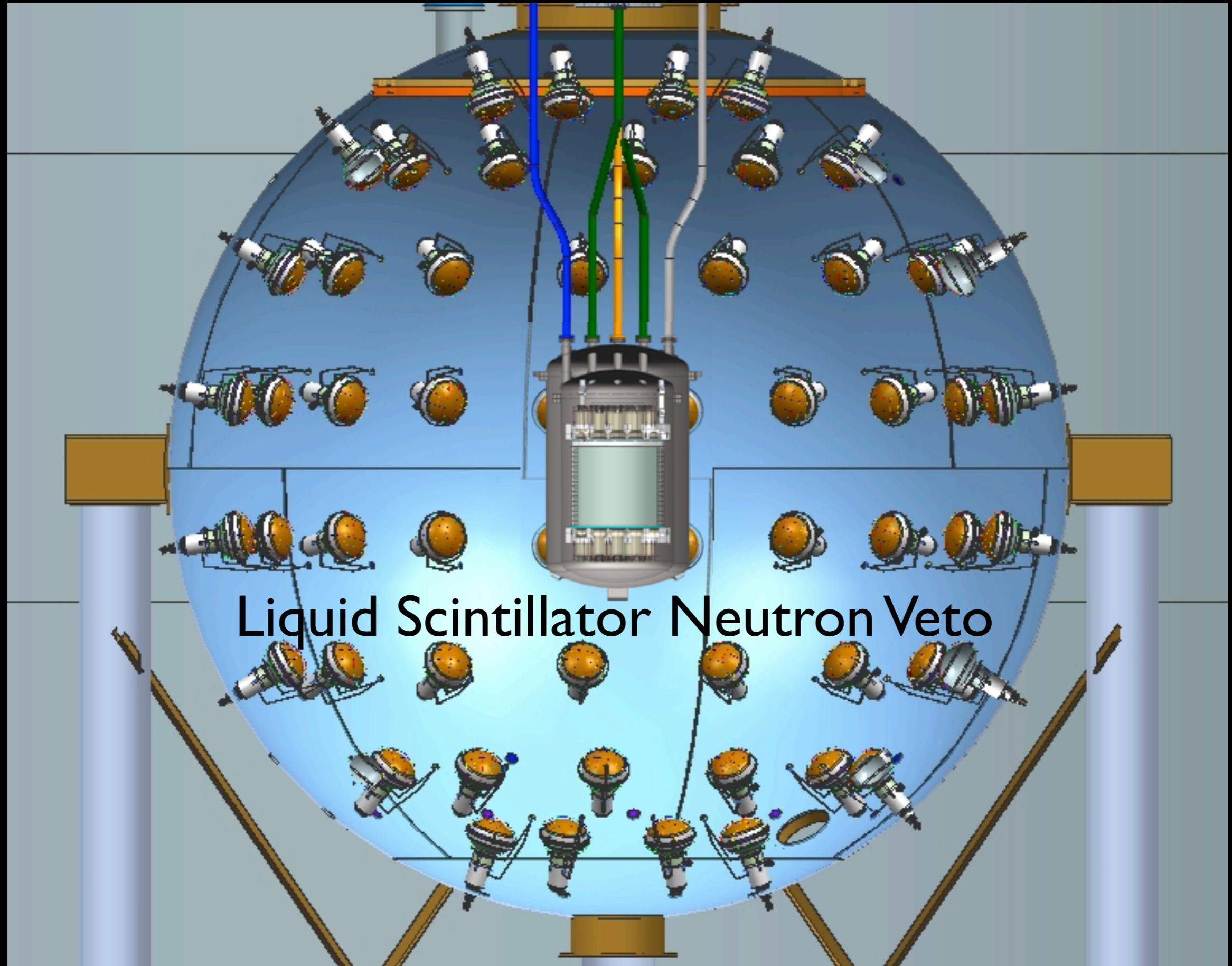
- Pulse Shape Discrimination (PSD) of Primary Scintillation, S1, (rejects e/gamma) (unique to Argon - atomic physics of Argon dimer)
- Ionization:Scintillation Ratio, S2/S1 (rejects e/gamma - not unique to Argon)
- Sub-cm Spatial Resolution (identify surface bkgs) (advantage of two-phase)
- Underground argon (avoid event pile-up from  $^{39}\text{Ar}$ )
- Neutron Veto (identify neutrons with high efficiency in finite volume)
- Water shield (identify muons and avoid cosmogenic neutrons)
- Screen and select all detector materials for minimum radioactivity

DS-50 LAr detector,  
within a neutron veto,  
within a muon veto,  
under a mountain  
  
both the vetoes are sized  
for DS-G2



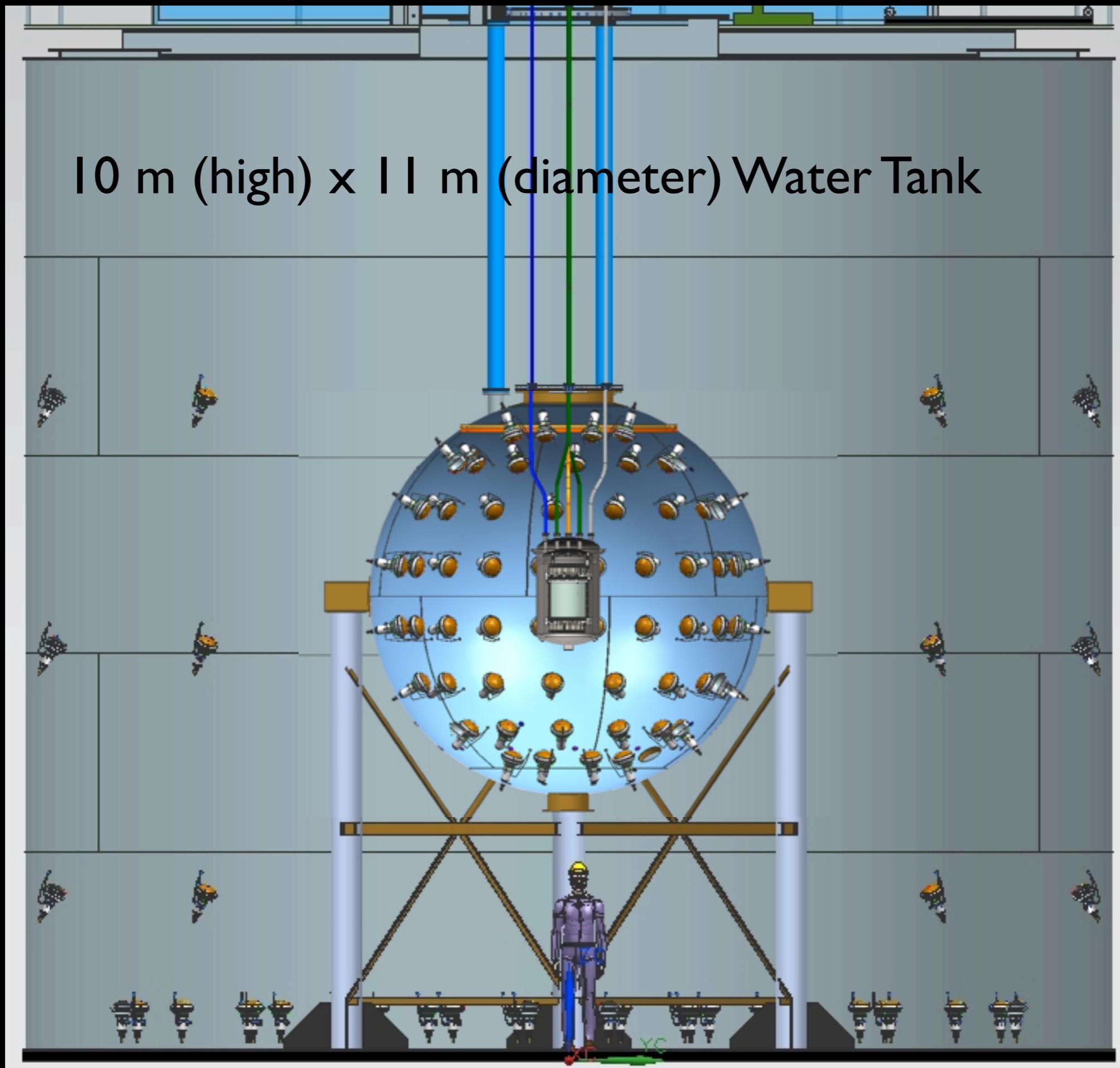
## Liquid Argon TPC & Cryostat

S. Pordes - DarkSide at A.E.M 12-3-2012



S. Pordes - DarkSide at A.E.M 12-3-2012

10 m (high) x 11 m (diameter) Water Tank



S. Pordes - DarkSide at A.E.M 12-3-2012

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S. Pordes - DarkSide at A.E.M 12-3-2012

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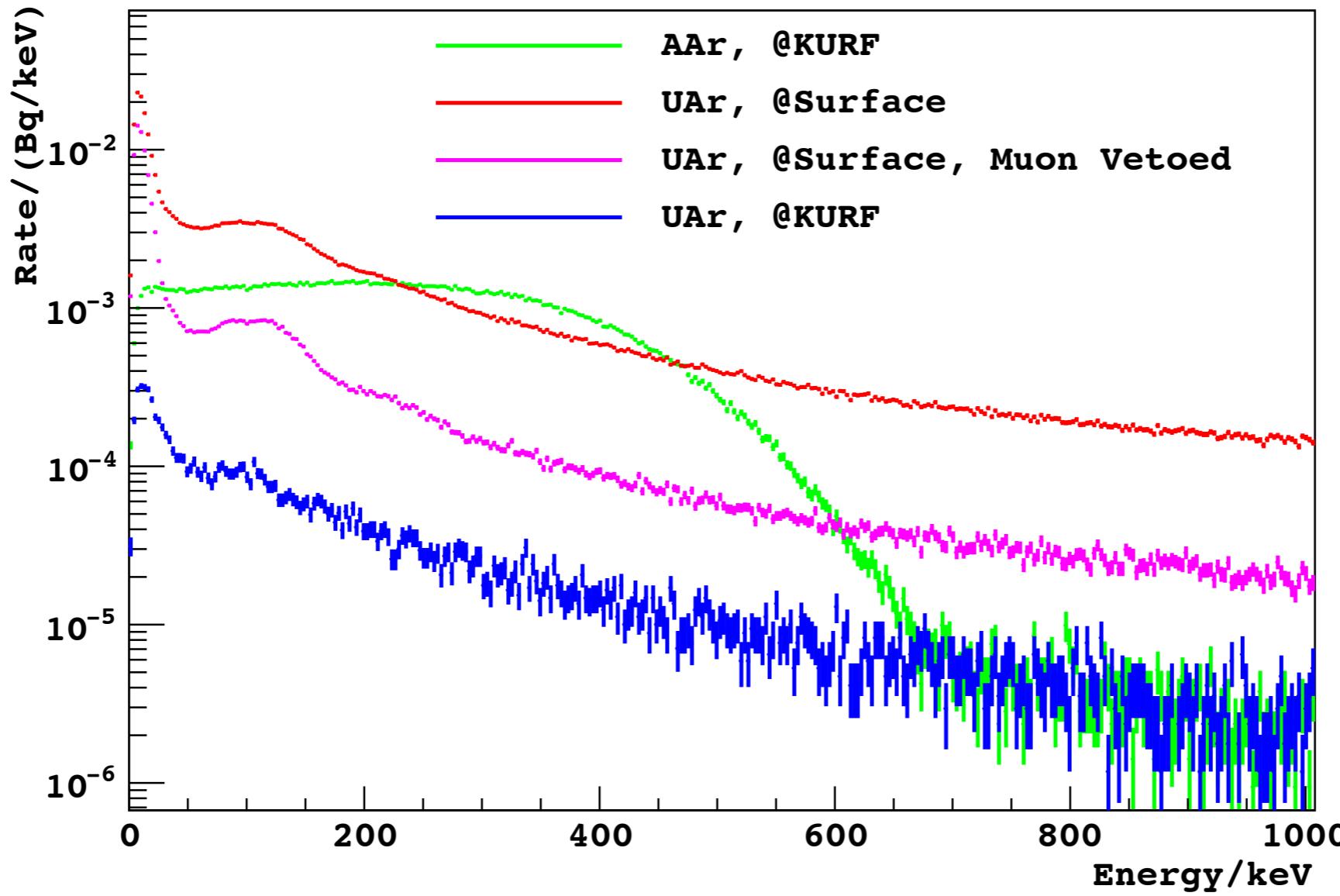
# DS-50 Project Funding

- NSF: \$6M in construction costs plus in kind contributions (Borexino infrastructure)
- DOE: slightly less than \$2M in construction funds
- INFN: \$2M in construction costs foreseen (still waiting for \$760k) plus in-kind contributions (CTF and BX infrastructure)

# Fermilab Participation in DS-50:

- Underground Argon Purification (PPD-ME & DDO *with Princeton*)
- Argon handling system (PPD-ME & DDO *with Princeton & UCLA*)
- TPC Data Acquisition System (SCD-NTL *with LNGS*)
- Trigger (PPD/EE)
- PMT Bases (PPD/EE)
- Project management & DOE funds co-ordination
- Data Storage (SCD-NTL) (& analysis) (under discussion in exp.)
- Source insertion mechanism (PPD-ME & DDO - proposed)

## Underground Argon Measurements



- <6.5 mBq/kg (cf 1 Bq/kg in atmospheric Argon - factor 150)
- 125 of 150 kg collected (Princeton operation), stable extraction at 1/2 kg/day

# Cryogenic Distillation Column

Assembled,  
commissioned and  
operated at the  
Proton Assembly  
Building  
(removes N<sub>2</sub> and He  
from Ar,N<sub>2</sub>,He mix)

Princeton-Fermilab  
collaboration

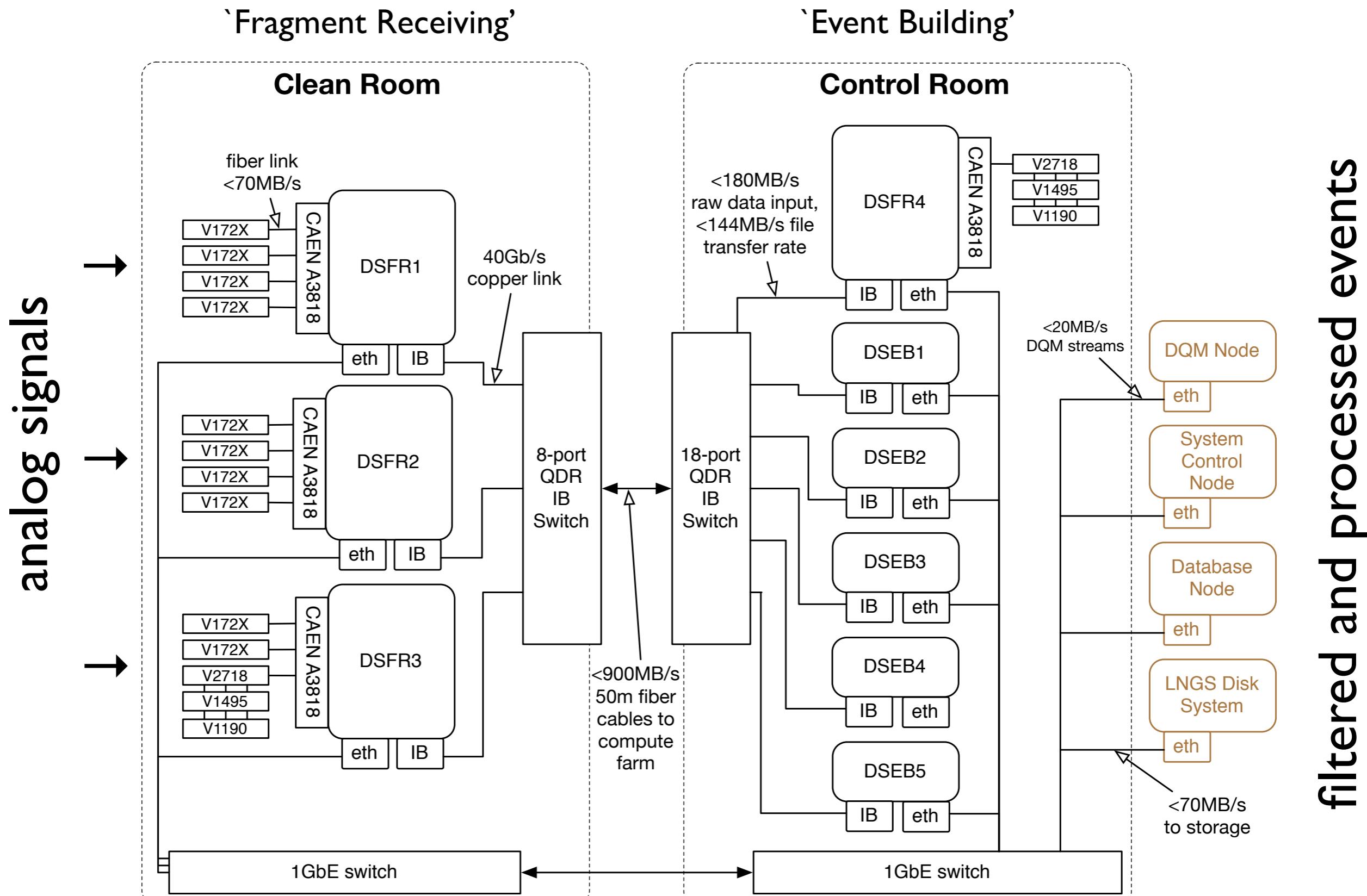


S. Pordes - DarkSide at A.E.M 12-3-2012

# Argon handling system - leaving PAB, and in clean room at LNGS



# DS-50 TPC DAQ Architecture



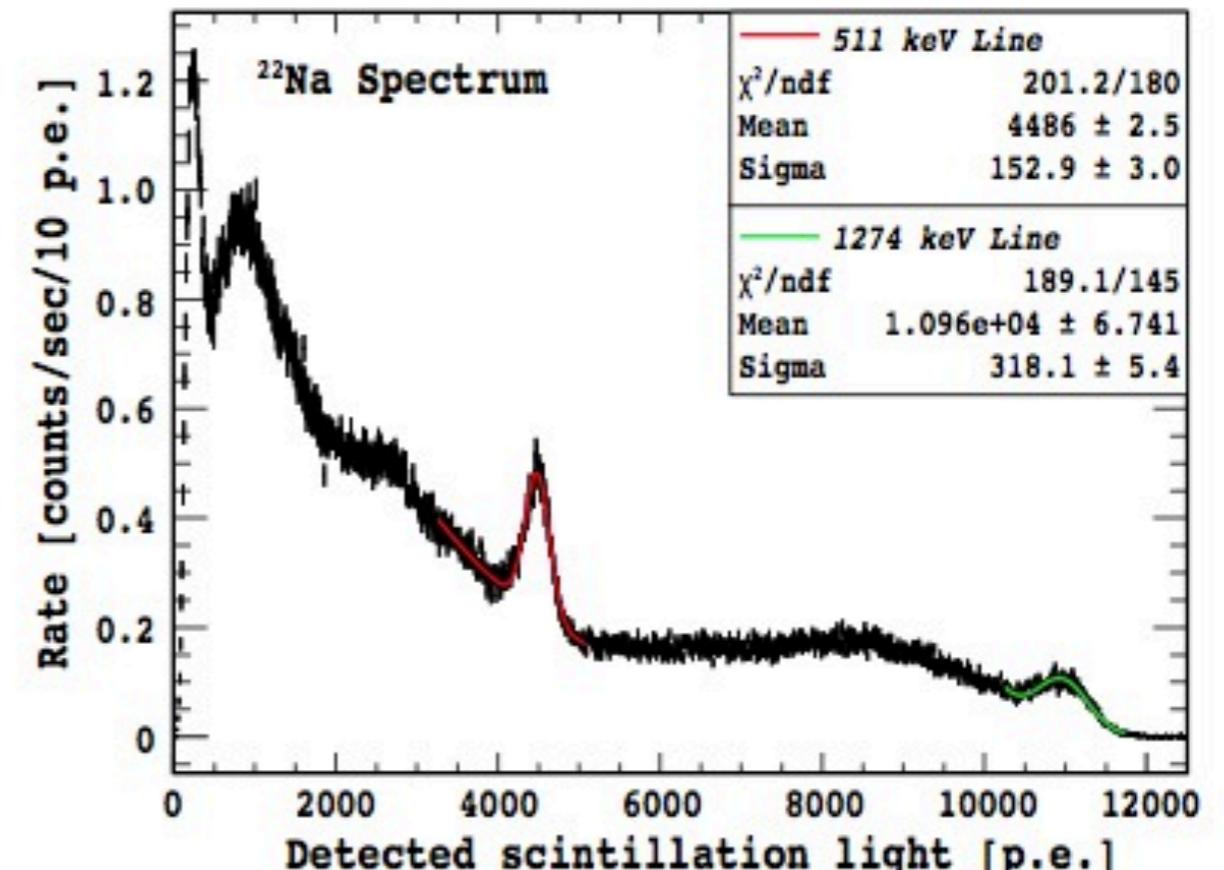
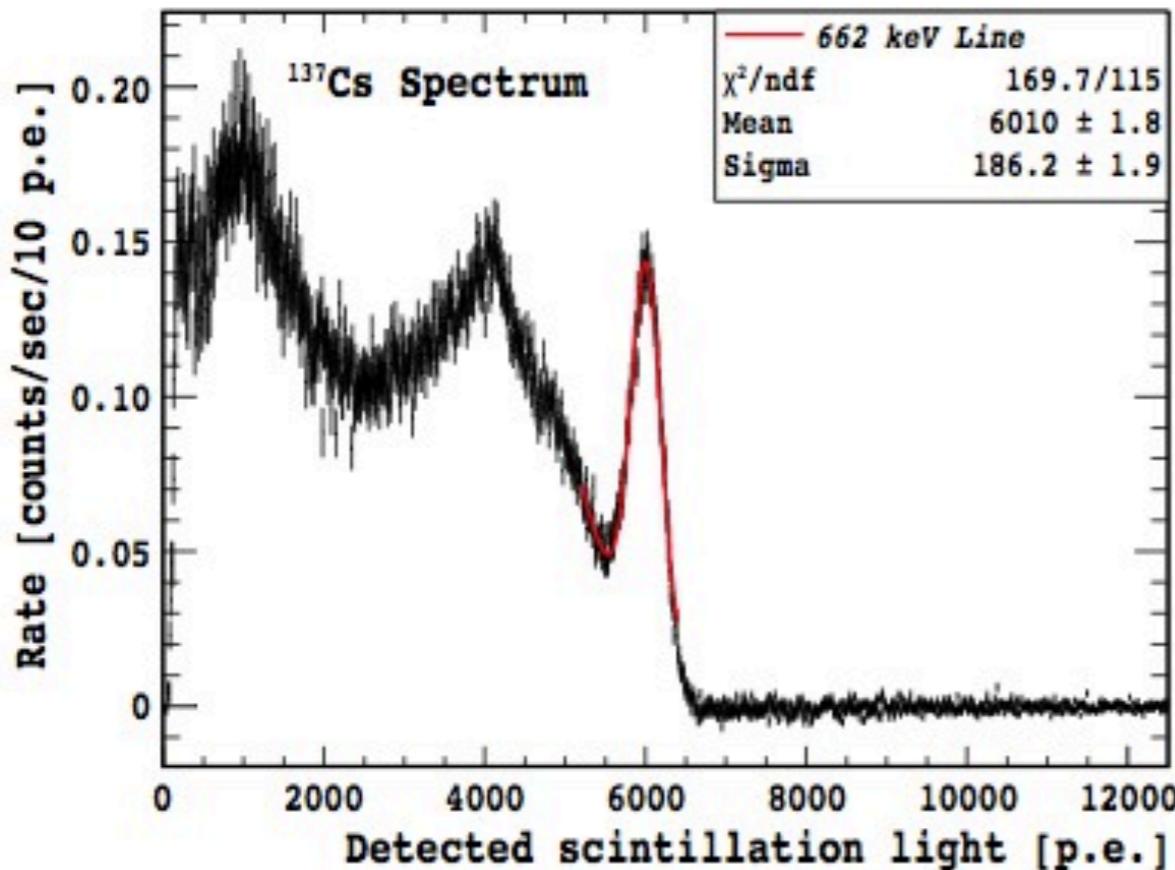
# Test System: DS-10 at LNGS



# DarkSide-10 Activities and Results

-  Compare performance of different reflectors for light collection
-  Perform long-term test of HHV system
-  Test detector calibration scheme and help refine calibration strategy
- Test of front-end amplifier for DS-50 TPC (ongoing)

# DarkSide- I 0

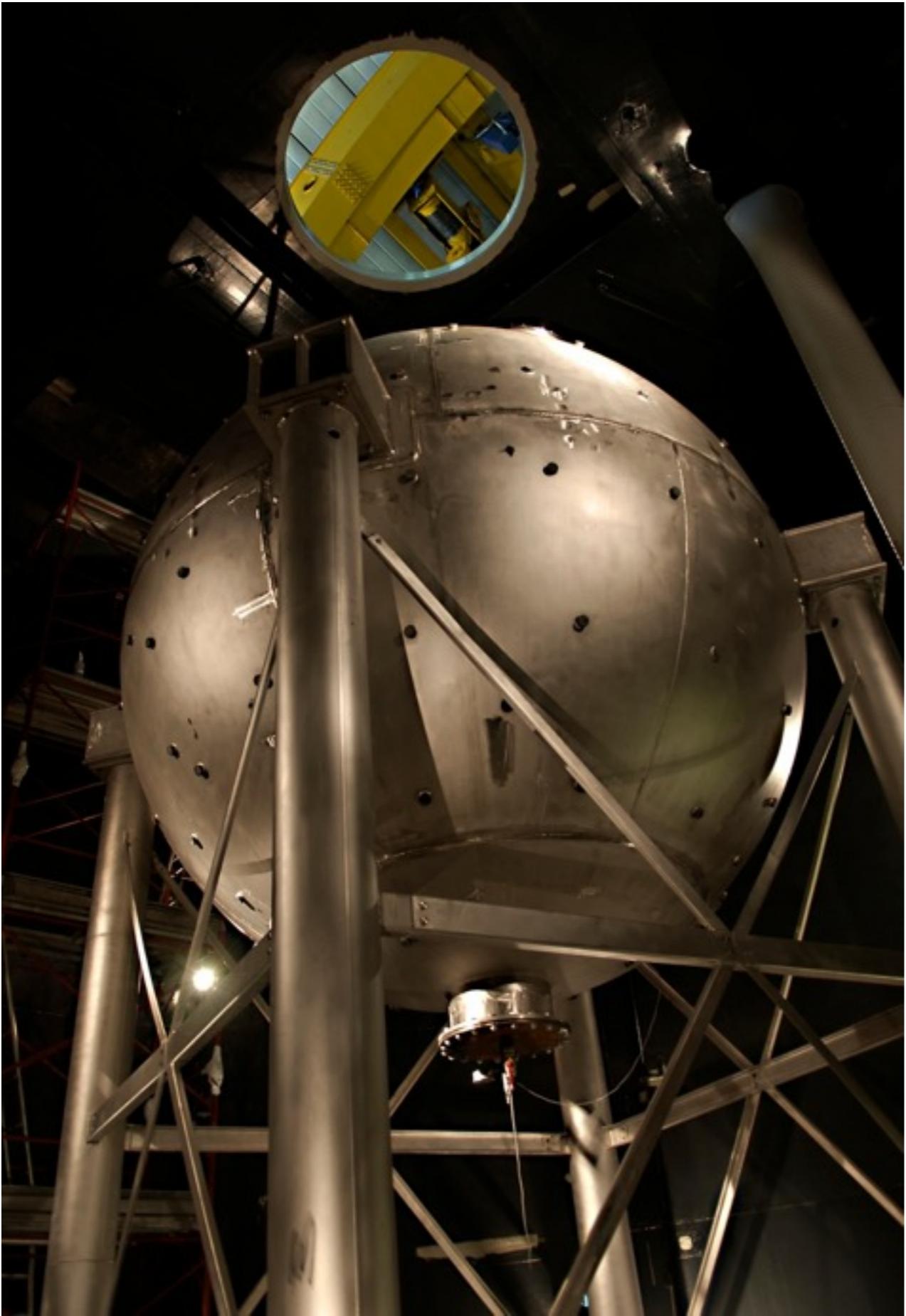


$\text{LY}=8.9 \text{ pe/keV}_{\text{ee}}$  - outstanding

due to new PMTs and effective TPB coating

# Report from LNGS

- Counting Test Facility of Borexino drained March 2012
- Liquid Scintillator Vessel build and completed May 2012
- Radon abatement system (230 m<sup>3</sup>/hr, reduction factor >10,000, <1 mBq/m<sup>3</sup>) delivered and commissioned September 2012
- Radon-suppressed clean room CRI for precision cleaning and evaporation of wavelength shifter completed September 2012
- Liquid scintillator and water loop completed and precision cleaned by September 2012
- Radon-suppressed clean room CRH for assembly (on top of CTF, 5 tons crane, direct access to liquid scintillator vessel) expected by end of 2012



Liquid Scintillator Vessel in Water tank



TPC Assembly - clean and radon-free room



Clean and radon-free room above water tank

# Recent Developments

- Granted NSF-DCL grant for R&D towards DS-G2
- Funding (\$0.95M) of expansion of extraction plant (50 kg/day) granted in FYI2 by NSF
- Completion of shields required for DS-G2 scheduled by December 2012

# DS-50 Schedule

>Title

## ▼ 1) DarkSide-50 Commissioning and Operations

### ▼ 1.1) TPC Commissioning

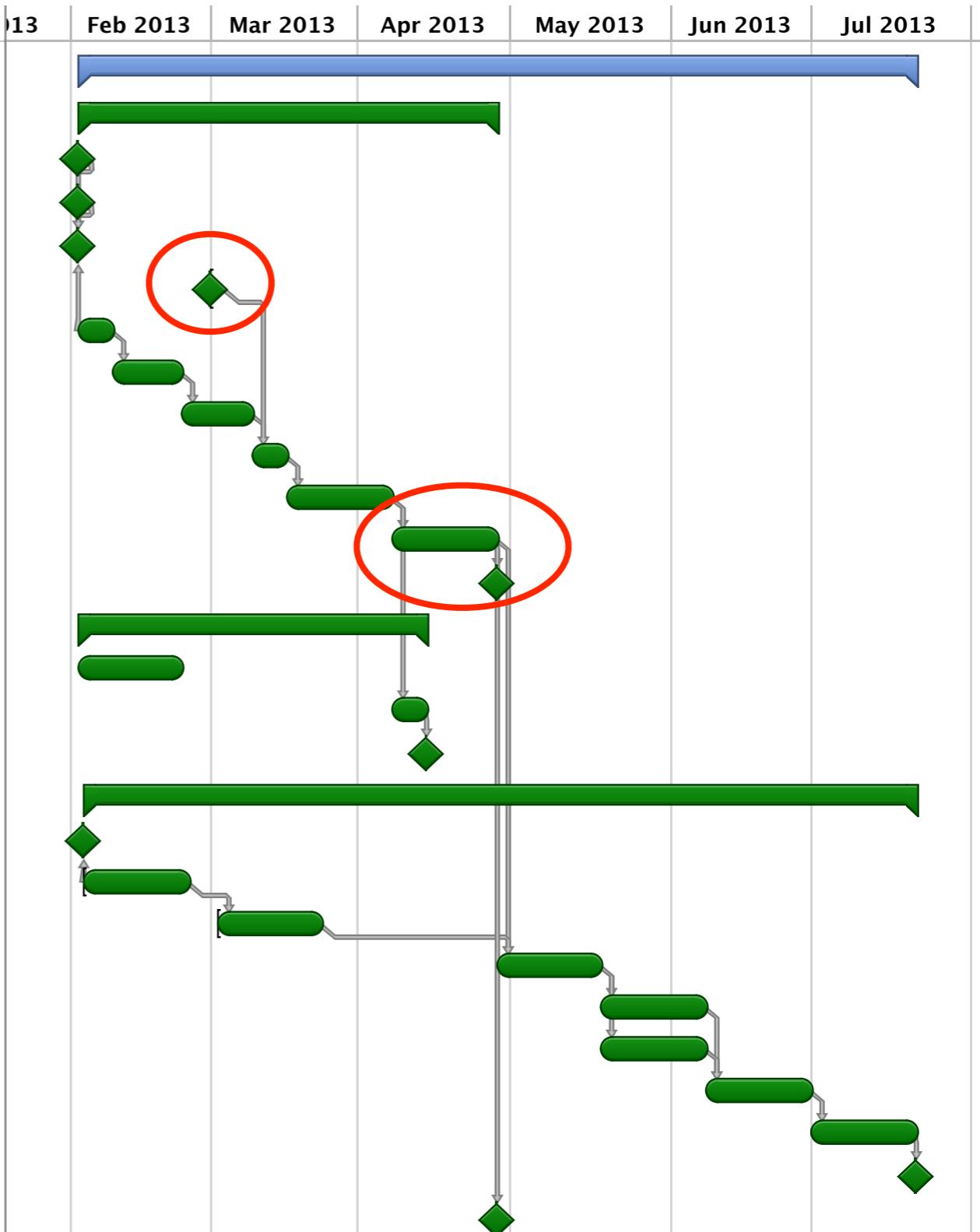
- ◆ 1.1.1) Installation of Inner Detector DAQ
- ◆ 1.1.2) Delivery of System Control
- ◆ 1.1.3) Start of TPC Commissioning in UAr cryostat
- ◆ 1.1.4) Completion of DAQ commissioning and debugging
- 1.1.5) Initial Checkout in Clean Room
- 1.1.6) UAr cryostat/TPC insertion in LSV/CTF
- 1.1.7) Prep work for first cool-down
- 1.1.8) Cool-down and fill with atmospheric Ar
- 1.1.9) Detector Checkout
- 1.1.10) TPC Performance evaluation
- ◆ 1.1.11) Completion of TPC Commissioning in LSV

### ▼ 1.2) Ar Supply & Recovery System Commissioning

- 1.2.1) Tests Ar Supply System @ LNGS
- 1.2.2) Test of Ar Recovery System
- ◆ 1.2.3) Completion of Ar Supply & Recovery System Commissioning

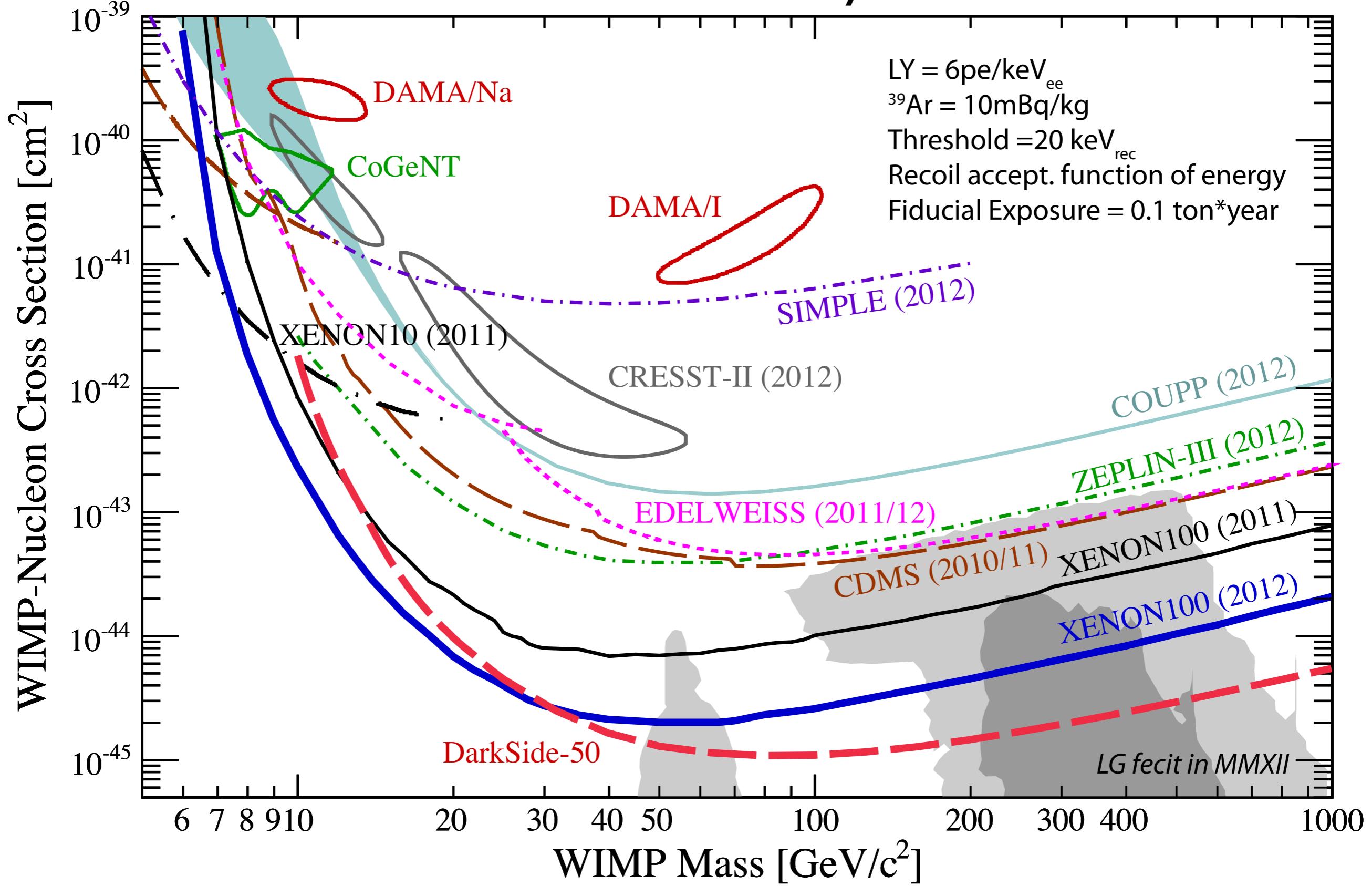
### ▼ 1.3) Outer Detectors Commissioning

- ◆ 1.3.1) Start of Outer Detectors Commissioning
- 1.3.2) Neutron Veto & Fluid handling system prep work
- 1.3.3) Neutron Veto PMTs test with Optical Fibers in N2
- 1.3.4) Fill LSV with Liquid Scintillator
- 1.3.5) Neutron Veto PMTs test in Liquid Scintillator
- 1.3.6) Muon Veto prep work and PMTs test
- 1.3.7) Fill Water Tank with water
- 1.3.8) Muon Veto PMTs test in water
- ◆ 1.3.9) Completion of Outer Detectors Commissioning
- ◆ 1.4) Start of Physics Data



# Backups

# DarkSide-50 Sensitivity Plot

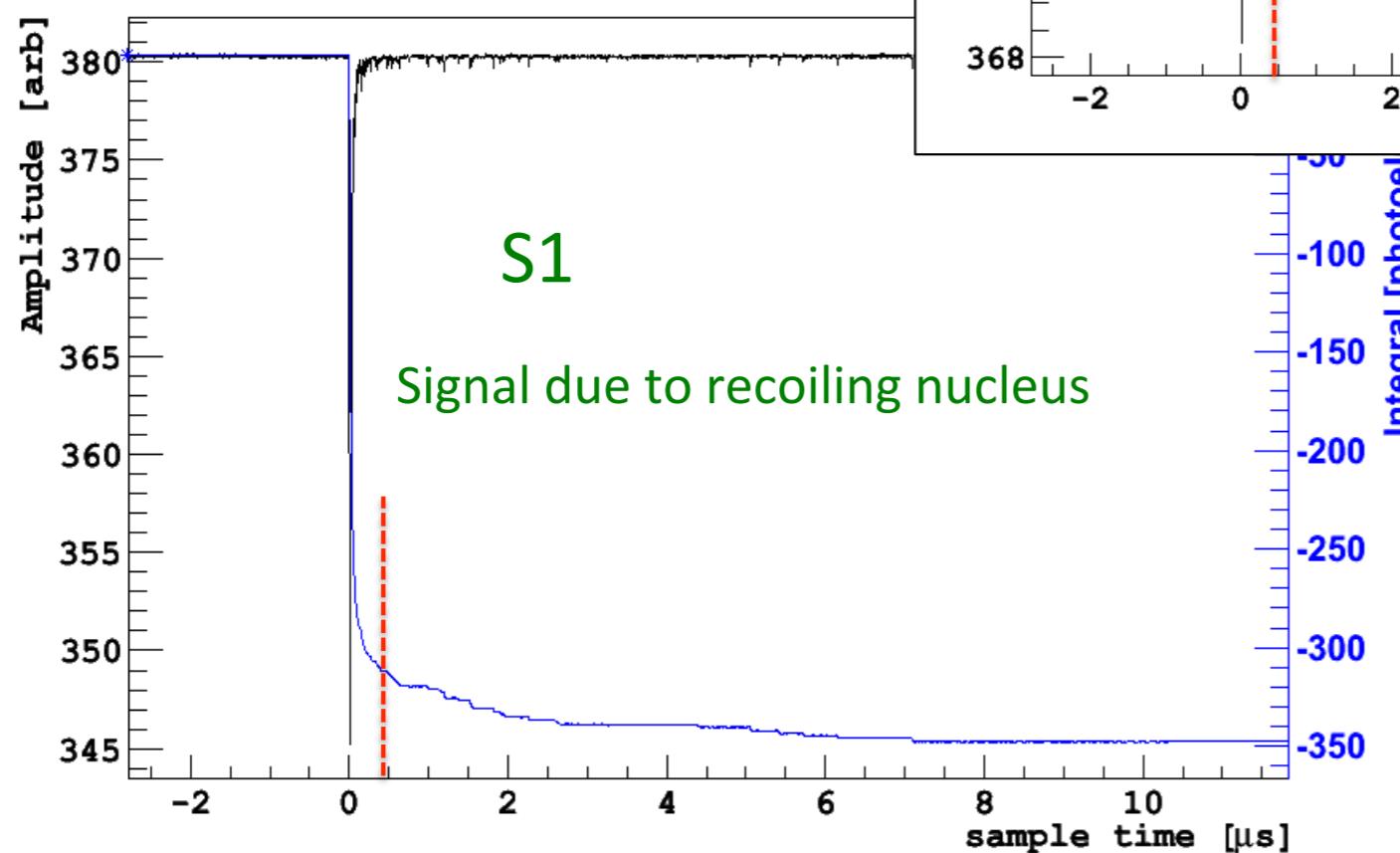




S1 signal shapes for

Electron event

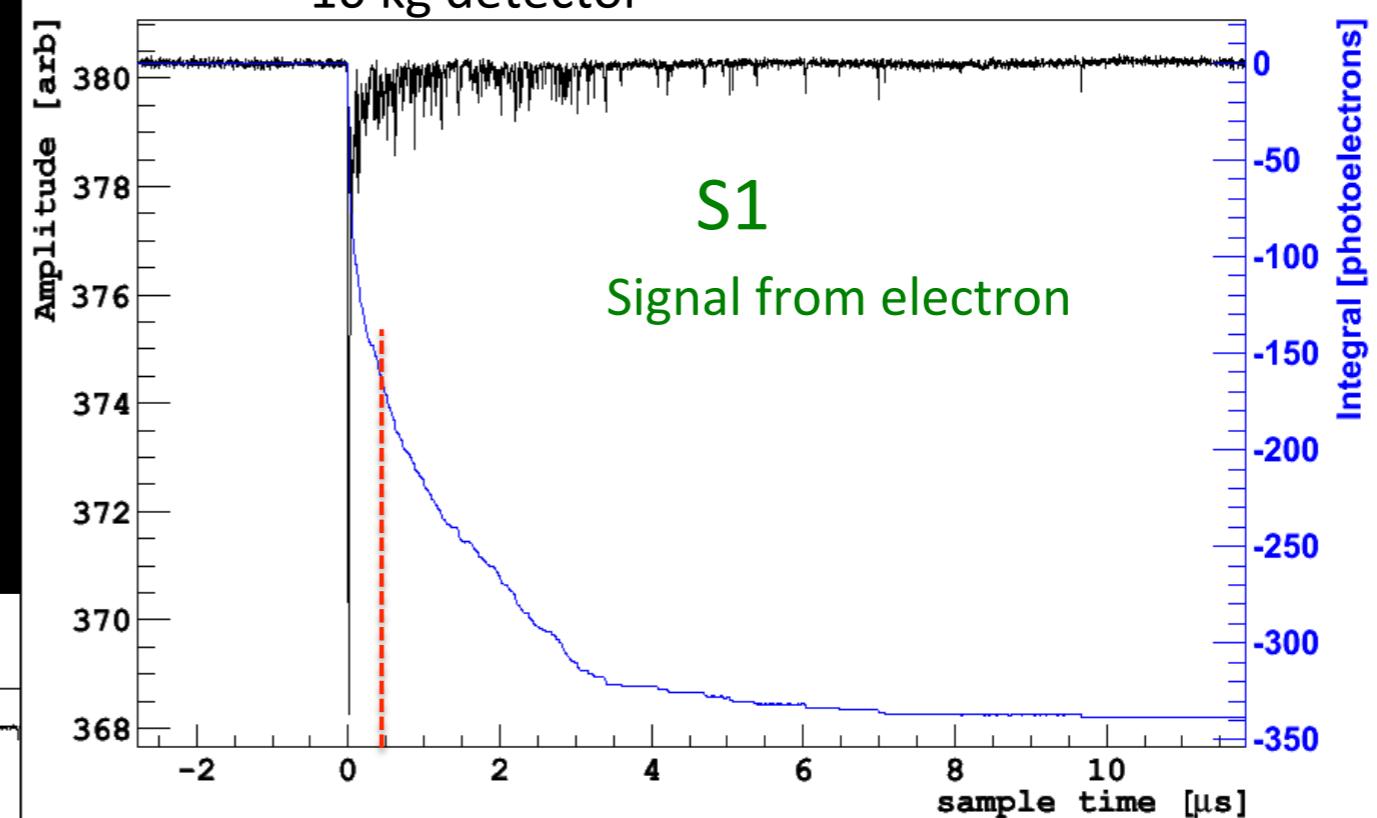
Nuclear recoil event



10 kg detector

S1

Signal from electron



Define **f90** =

Fraction of integral  
in first 90 ns

